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COMPARISON OF THE FUEL NEEDED TO TRANPORT PLASTIC RECYCLABLES VERSES ALUMINUM RECYCLABLES FROM YELLOWSTONE NATIONAL PARK

By

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COMPARISON OF THE FUEL NEEDED TO TRANPORT PLASTIC RECYCLABLES VERSES ALUMINUM RECYCLABLES FROM YELLOWSTONE NATIONAL PARK

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Research has provided no definitive answers on whether PET plastic bottles or aluminum cans are a more environmentally sustainable choice as soda containers. This paper researches the fuel used in recycling each of these materials from Yellowstone National Park to processing locations. The data is used to determine which of these alternatives use less fuel in this process. It was found that plastics use more fuel when transported from Yellowstone National Park to the processing center. Aluminum uses less fuel per ton to transport from Yellowstone to the processing center. The conclusions from this research may have implications on which material would be advised to use in selling soda in Yellowstone National Park.

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Chapter 1. Introduction

The objective of this thesis is to use written materials and interviews to compare the fuel that is needed to transport plastic recyclables and aluminum recyclables from Yellowstone National Park to the place where the materials are finally processed. The findings of this study determine if soda containers that are made of plastic use less fuel when transported to the recycling facility than aluminum soda containers. The null hypothesis is that the transportation of plastics from Yellowstone National Park to the facility that recycles plastics has less of an environmental impact than the transportation of aluminum to its respective recycling facility.

Chapter one states the objective of the paper and gives an overview of the different chapters in the thesis. Chapter two is a literature review on the environmental impacts of plastic and aluminum beverage packaging. Chapter three describes the development of the thesis. Chapter four gives the background of recycling in Yellowstone National Park. Chapter five outlines the methods used to collect data in order to prove or disprove the null hypothesis. Chapter six shows the data that was collected. Chapter seven describes and lays out how the data was analyzed. Chapter eight discusses the conclusion found by the data collected. Finally, chapter nine is the discussion about the conclusion and how the findings relate to everyday soda consumption. This chapter also looks at the possibility for further research.

Chapter 2. Literature Review

In 2005, the average American drank 100 gallons of packaged beverages (Gitlitz, 2007) while 49.3 gallons of soda were consumed by the average American in 2007. With such large amounts of packaging being used for beverages, it is important to look at the environmental affects of each of the packaging materials.

Packaged soda is the largest percentage of packaged beverages sold in the United States (Gitlitz, 2007). It is sold in plastic bottles and aluminum cans which both have negative impacts on the environment. When a consumer is looking for the least environmentally damaging package, there are many factors to take into consideration. One of these factors would be the raw materials that are needed for production of the packaging. The energy used in making and recycling the packaging and the pollution that is caused by the processing of these products should also be considered. Finally, the ability to market the recycled materials influences which materials will be recycled in larger quantities. Finding the most environmentally safe packaging is a complex process, and there is no consensus on whether plastic or aluminum is the best choice.

The beginning of all packaging starts with the raw materials used to produce it. Soda bottles are made of polyethylene terephthalate or PET plastics. PET plastics are derived from oil or natural gas feedstock. Both of these raw materials are non renewable resources that have a finite supply and will eventually run out. Oil is reached by being pumped from the ground which can cause environmental degradation in the areas of the extraction site. Pipelines that are used to transport these resources can also cause disruptions in animal migrations and oil leaks that affect plant growth and poison animals. There is a limited supply of petroleum in the United States which means that most of the raw materials that form plastics come from other countries. The week of November 14 2008, the United States imported over 12 million barrels of crude oil and petroleum products while it exported less than 2 million barrels (Energy Information Administration, 2008). Shipping the petroleum from other countries to the United States contributes to the fuel use and pollution that is generated in the plastic making process. There is also a greater chance of pollution due to an oil leak when the raw materials are transported long distances. The petroleum and natural gas that is used to produce PET plastics have several negative impacts on the environment such as the degradation of land at the drilling site and the transportation of the petroleum to a processing center.

The raw material used to make aluminum cans is bauxite. Bauxite, or aluminum ore, must be extracted from the ground by mining. These mines are usually open pit mines which require the clearing of forests and degrade large areas of land. These open cast mines have also displaced the people that used to live on these lands. There is a possibility of water pollution resulting from these mines. Digging these large mines can have a significant affect on the hydrology of the area. The most common water problems are turbidity, stream yields, and stream salinity (Croton, 2007). Moving large amounts of soil to reach the bauxite also requires large amounts of energy as well as the transportation of this raw material. Most bauxite is found in developing countries, which means to manufacture it the ore must be transported to more industrialized areas of the world. The raw material of bauxite must also be extracted from the ore unlike the reused aluminum. The aluminum smelting process continuously evolves both sulfur dioxide and hydrogen fluoride gases. These gasses are normally vented and treated, however, if a leak occurred it would be undetectable due to lack of technology in monitoring these gases (Dando, 2008). The release of dibenzo-p-dioxins or PCDDs and polychlorinated dibenzofurans, PCDFs, has become a serious issue in many countries because of the toxicological effects and the adverse health conditions that these gases may cause (Lee, 2004). Getting and processing bauxite into aluminum may cause many negative outcomes that could be avoided by recycling.

The extraction and processing of the raw materials to make PET plastic bottles and aluminum cans both have impacts on the environment, but it is difficult to compare the impacts of the raw materials used to make aluminum to those used to make PET plastic because they affect the environment in different ways. Another aspect of each of these materials that should be considered is the energy consumption by the manufacturing of these products when compared to recycling.

Recycling aluminum saves more energy than recycling plastics. Aluminum has an energy savings of over 90 percent when it is made from recovered materials rather than virgin materials. The energy savings from using recovered plastic instead of virgin oil or natural gas is less than 80 percent (United States Environmental Protection Agency, 1998). However, aluminum can be recycled back into aluminum cans in as little as six weeks and are also able to be recycled multiple times. PET plastics are usually not turned back into plastic bottles in the United States. They are often recycled into other products, such as polyester, synthetic fleece, and carpet fibers. The process of recycling plastics does not sufficiently polarize organic contaminants in the plastics, so the plastics are rarely processed back into food containers (Marsh, 2007).

Another factor in the debate of plastic bottles versus aluminum cans is the marketability of the recovered recyclable material. Aluminum cans are the highest valued municipal solid waste material with a value of one billion dollars in 1997. Plastics were valued at less than 200 million dollars at this time (United States Environmental Protection Agency, 1998). The processes that plastics must go through to be separated into the different resins raise the cost of recycled plastic. However, the capacity to process the resins and the demand for the recovered plastic exceeds the amount of post-consumer plastics recovered (United States Environmental Protection Agency, 2008).

It is still unclear whether aluminum cans or plastic bottles make less of an environmental impact when recycled. It is clear that aluminum is recycled more than plastics nationally. Plastic is recycled at a rate of 30 percent while aluminum is recycled at a rate of 45 percent in the United States (Container Recycling Institute 2007). Recycling has reduced the amount of municipal solid waste going to the landfills in the United States, but there are still environmental impacts from using recycled packaging as well as packaging from virgin materials. Soda containers are only a small part of the municipal solid waste we dispose of in the United States, but finding the least environmentally damaging product can make big differences when the average American is consuming over 49 gallons of soda a year.

Chapter 3. Development of Thesis

There was found to be no definitive answer in the research of aluminum cans and plastic bottles to determine which caused less degradation to the environment in the United States. With the lack of information, there has been no consumer movement or governmental policies proposed to change the current choices in soda container packaging. More research is needed to determine if the benefits from one of the packaging alternatives is greater than the other and warrants a change in production. Researching the environmental impact of each packaging product on a local level may reveal environmental changes that affect only that area and could be changed on a local level.

Yellowstone National Park was chosen as an area of research due to the large number of visitors each summer and the ability of Yellowstone National Park to change its policies and control the markets inside of its boundaries and choose the most sustainable option.

An initial thesis proposal was made to compare the weight of recyclables and trash going to the landfill from one of the service stations within the Yellowstone National Park boundaries. This research would have given information on the diversion rate of plastic and aluminum in the park compared to the rate of municipal solid waste going to the landfill. This option was not chosen because there has been diversion rate analysis done in the park before. These statistics grouped aluminum and steel in one group and all the different plastic resins into another group (United States Environmental Protection Agency, 2006). This did not show if aluminum or PET plastics had a higher recycling rate because of the other materials grouped with them. Plastic bottles are the dominant packaging material for beverages in the park. This would have skewed the data to show that more plastics were being recycled when actually the higher rate could be a consequence of the higher availability of the plastic packaging. It was determined that these results would have many variables that would make the data inconclusive.

A second proposal was discussed which involved the surveying of park visitors. Questions would be asked about their preference of plastic bottles or aluminum cans for soda packaging and their concern level about the environmental affects of each. The data from this proposal would have showed the public interest in determining a more environmentally sustainable choice and if high responses to the concern level were found, this would initiate further research into the topic. The difficulty with this proposal was that all surveys done in Yellowstone National Park must have a special use permit granted by the National Park Service. The time constraints on obtaining such a permit did not allow this option to be pursued.

The third option was to compare the recycling rates of fueling stations in the park with fueling stations outside of the park. The purpose of this option would be to determine if the recycling programs that the park has instituted increased recycling rates at a certain type of business. First, it was found that most fueling stations outside of the park did not recycle at all. Second, there was difficulty in finding a feasible way to measure the recyclables and non-recyclable trash outside of Yellowstone National Park due to the fact that the recyclable and non-recyclable waste is not measured by most fueling stations and would involve weighing large amounts of garbage.

Finally, it was decided to take the remote geographical location of Yellowstone National Park into consideration. Yellowstone National Park is known for the vast amount of national forest that surrounds it creating one of the largest undeveloped areas in the United States excluding Alaska. The remote location of Yellowstone National Park leads to many challenges including the shipment of recyclable waste to processing centers. The final thesis proposal is the comparison of fuel used to transport recyclable aluminum and the amount of fuel used to transport recyclable PET plastics out of Yellowstone National Park to processing centers.

Chapter 4. Background

Yellowstone National Park is located in a remote region. While this park is removed from any large cities, Yellowstone sees nearly 3 million visitors a year. The large number of visitors creates a significant amount of solid waste. In 1997, the National Park

Service started the “Greening of Yellowstone” project. This project was intended to address many sustainability issues in the park including solid waste.

A previous waste management study conducted in 1994 showed that 60% to 75% of the waste in Yellowstone could be recycled or composted (U.S. Department of Energy, 2000). This led to the creation of Headwaters Cooperative Recycling, Inc which joined nine counties, five cities, and Yellowstone National Park encompassing 35,000 square miles (Headwaters Cooperative Recycling Inc.). The combined resources of this large area made a recycling program possible for each of these communities that could not support a recycling program on their own.

In 1999, the National Park Service developed a program called Environmental Leadership. This program educates the national park visitors on many different sustainability issues including waste management (Norton, 2000). The diversion rate of solid waste in Yellowstone National Park grew by 60% from 2001 to 2005 due to visitor education and the wide spread distribution of recycling containers throughout the park. There were 631 tons of recyclables collected in the park in 2005 including 21.7 tons of steel and aluminum and 10.3 tons of plastics (United States Environmental Protection Agency, 2006).

One of the significant environmental affects of recycling in Yellowstone is the long distances that must be traveled to recycle both aluminum and plastic. To get these recyclable goods to cities where they can be processed requires trucks to cover great distances. First, the recyclables are loaded onto a tractor trailer with multiple bins for the different recyclables. Then these recyclables must be transported from Yellowstone National Park to the city where the recovered material can be processed.

The extensive transportation distances using diesel powered vehicles creates many sustainability issues. First, there is the depletion of the fossil fuel reserves and pressures to drill in areas that are set aside for wildlife protection. Second, diesel vehicles produce carbon dioxide and carbon particulates that contribute to greenhouse gasses in the atmosphere and are linked to global climate change. The use of renewable fuels has been implemented for some of the park service vehicles, but nothing has been suggested about turning the Headwater Recycling, Inc. trucks into vehicles that can use renewable fuels (U.S. Department of the Interior, 2005). Finally, the price of oil on November 14, 2008 was $50.23 per barrel (Energy Information Administration, 2008). This is lower than it has been in previous months, but the price of oil could always go back to a price of over $100 per barrel that was seen earlier in 2008. The cost of fuels to transport the recovered materials can cause consequences on the economic sustainability of this recycling cooperative.

Chapter 5. Materials and Methods

First, the distance from the north gate of Yellowstone National Park to A&S Metals was determined from maps of the area. The type of vehicle that is used for the transportation of the recovered materials was discovered through observation. Then, the type of vehicle used and the load weight of the recovered materials in the truck were used to find the average fuel mileage of a similar vehicle.

The distance from A&S Metals to the final destination of each of the two products was taken from maps of the area. Data about the weight of the loads from A&S Metals and information on the type of vehicle used to transport the recovered materials were acquired through interviews. This information and the average fuel mileage of a similar vehicle with a comparable load were used to determine the gallons per ton that is needed to transport the raw recyclable waste. Finally, all of the calculations were converted into gallons per ton to more easily analyze the data.

Chapter 6. Data

Bill Crane, the general manager of Headwaters Cooperative Recycling, Inc., was contacted by telephone and stated information on the recyclables from Yellowstone National Park. The recovered materials are transported by a tractor trailer that has four bins containing paper, glass, aluminum cans, and PET plastics. This 53 foot trailer can carry up to 10 tons of recyclables. These trucks are filled to capacity once or twice a week during the summer season in Yellowstone National Park. The paper, plastic, glass, and aluminum are transported to A&S Metals in Butte, Montana. This costs the park service $200 per ton for removal where as before the park service was paying $400 per ton to take the materials to the landfill (Crane, 2008).

Ed Wilcox who is the yard manager at A&S Metals was then interviewed. He said that the aluminum is sent from A&S Metals to an Anheuser-Busch recycling center in Louisville, Kentucky. The aluminum is loaded on trucks that carry 22.5 tons of material. Mr. Wilcox reported that the PET plastics are transported to Spokane Recycling in Spokane, Washington. The weight of the plastics that can be transported in one truck is the same as the aluminum at 22.5 tons (Wilcox, 2008).

Mike Young, a broker for Spokane Recycling was then consulted. He stated that Spokane recycling sells the recyclable PET plastics to a company in Calgary, Alberta Canada. The PET plastics are transported by semi tractor trailer from Spokane to Calgary (Young, 2008).

Next, Antoine Moucachen of Merlin Plastics in Calgary, Alberta was contacted. He confirmed that they are the company that receives the PET plastics from Spokane Recycling. The plastic bottles are shipped there on tractor trailers and there is approximately 20 tonnes on the truck that goes from Spokane to Calgary. There the plastic bottles are cleaned and turned into RPET flakes to be sold to companies to make textiles and other recycled products (Moucachen, 2008).

Finally, the fuel mileage of a semi tractor trailer carrying approximately the same amount as the trucks was found in a reputable publication. This publication stated that the average fuel mileage is 5.8 miles per gallon for trucks that are able to carry 22.5 tons of material (Davis, 2007).

Figure 1. Shipping Distances of Recovered Aluminum and Plastic from Yellowstone National Park

Source: www.freeworldmaps.net

Chapter 7. Data Analysis

A simple comparison was used to look at the difference between fuel use in transporting PET plastic containers and aluminum containers. The total gallons of fuel used to move one ton of PET plastic containers were compared to the amount of fuel used to transport one ton of aluminum containers. To find this, the number of miles traveled to each location was multiplied by the average fuel mileage of a loaded tractor trailer. This resulted in the total fuel used for each leg of transportation. The total gallons of fuel used were divided by the weight of the recyclable on the trailer to get the fuel used to move one ton of each of the recyclables. Then, the data from each leg of the journey was added together to result in the total fuel per ton used to transport one ton of each of the recyclables. The data is shown in Table-1 for the PET plastic and Table-2 for aluminum.

Table 1. Fuel Used to Transport One Ton of PET Plastics from Yellowstone National Park

	Weight of Plastic on Truck (tons)	Miles Traveled	Fuel Efficiency of Truck (miles per gallon)	Fuel Used (gallons)	Gallons of Fuel Used Per Ton of Plastic
Yellowstone National Park (North Gate) to A & S Metals Butte, Montana	0.9723	162.5	5.8	28.02	28.82
A & S Metals Butte, Montana to Spokane Recycling Spokane, Washington	22.5	315.18	5.8	54.34	2.415
Spokane Recycling Spokane, Washington to	22.05	432.51	5.8	74.57	3.382

Merlin Plastics Calgary, Alberta					
Total					34.61

Table 2. Fuel Used to Transport One Ton of Aluminum from Yellowstone National Park

	Weight of Aluminum on Truck (tons)	Miles Traveled	Fuel Efficiency of Truck (miles per gallon)	Fuel Used (gallons)	Gallons of Fuel Used Per Ton of Aluminum
Yellowstone National Park (North Gate) To A & S Metals Butte, Montana	1.6668	162.5	5.8	26.02	16.81
A & S Metals Butte, Montana To Anheuser-Busch Recycling Louisville, Kentucky	22.5	1761.49	5.8	303.71	13.50
Total					30.31

The weight of the PET plastic on the truck leaving Yellowstone National Park was computed by the following: a 53 foot trailer has the dimensions 53’ x 8.53' x 13.5' = 6103.215 cubic feet assuming 103.215 feet are lost due to bin space, 6000 cubic feet remain and this is divided by the 4 bins on the trailer. This results in a volume of 1500 cubic feet per bin approximately 55.56 cubic yards. Whole PET plastic containers have a weight of 35 pounds per cubic yard (Volume-to-Weight). This gives a weight of 1944.6 pounds or 0.9723 tons. In Table-1 and Table-2, the weight of the plastic and aluminum leaving A&S Metals was known by Mr. Wilcox. The figure of 22.5 tons is the same for the plastic and the aluminum due to weight restrictions of tractor trailers on United States highways. The weight of the PET plastics leaving Spokane Recycling going to Merlin Plastics was given by Mr. Moucachen of Merlin Plastics as 20 tonnes. Tonnes were converted to tons to get the value of 22.05 tons.

The weight of aluminum on the truck leaving the park was found in a similar manner as the plastics. The bins on the Headwaters recycling truck hold 55.56 cubic yards. This figure is the same as the calculations for the plastics. Whole aluminum cans weigh 60 pounds per cubic yard (Volume-to-Weight). This gave a weight of 1.6668 tons. As stated before, the weight of the aluminum cans on the truck leaving A&S Metals was 22.5 tons.

The results of these calculations showed that it takes approximately 34.61 gallons of diesel fuel to move one ton of PET plastic from Yellowstone National Park to Merlin Plastics in Calgary, Alberta where it is made into plastic flakes to be sold to companies for use in new products. It takes 30.31 gallons of diesel fuel to transport one ton of aluminum containers from Yellowstone National Park to Anheuser-Busch Recycling in Louisville, Kentucky.

Chapter 8. Conclusion

The calculations have disproved the null hypothesis. The null hypothesis stated that transportation of plastics from Yellowstone National Park to the facility that recycles it has less of an environmental impact than the transportation of aluminum to its respective recycling facility.

It takes less fuel to transport one ton of aluminum from Yellowstone National Park to a recycling facility than it takes to transport one ton of PET plastic from Yellowstone

National Park to a recycling facility. The major factor that leads to this conclusion is the volume to weight ratio of whole aluminum cans and whole PET plastic bottles. The restriction of highway weight limits no longer affected the amount of recyclables being transported due to the smaller loads on the Headwaters Recycling, Inc. truck. This means that many more trips would have to be taken from Yellowstone National Park to A&S Metals to get as many tons of plastic there as aluminum.

Chapter 9. Discussion

The major distinction in fuel used in transportation is the section of the trip from Yellowstone National Park to A&S Metals. This is because volume becomes a factor in the amount of different recyclables that can be taken. The weight of plastic bottles is slightly smaller than that of aluminum cans. Approximately 32 PET bottles make a pound of material where as it takes approximately 30 aluminum cans to make a pound (Das, 2006). However, plastic bottles also hold more liquid. These factors make it difficult to determine overall benefits of aluminum weighing slightly more and plastic holding slightly more when it comes to fuel use in recycling.

The data on the first section of transportation may also be above the actual amounts because it was assumed that the trucks were carrying only that recyclable when in reality the trucks carry paper, plastic, glass, and aluminum. Most of the fuel used in transportation is used to move the vehicle itself, so I did not find that the differences in weight of recyclables would change the fuel needed to move them by large enough margins to calculate. To find exactly how much fuel is used to transport only one recovered material would take further calculations.

Aluminum cans are easier to flatten than plastic bottles, which makes shipping them in large quantities easier and makes them more dense (Volume-to-Weight). The factor of density of the recyclable is negated when carrying only one recyclable due to weight limits on semi trailers on United States highways. However, when there was a set limit to the volume that could be transported, such as on the truck from Yellowstone National Park, it was found that volume to weight ratios can make a large difference on fuel use. This transportation method is also when the recovered material is not compacted which lessens the amount of materials that can be transported.

An unexpected discovery was finding that the aluminum cans were sent to Kentucky. This was a much longer distance than expected. The high price of virgin aluminum causes the demand of recovered aluminum to rise and the money to transport the recyclable across the country can be justified by a business because recovered aluminum costs much less than virgin aluminum. Plastics are sent a much shorter distance because the value of PET flakes is not high enough for manufacturers to use recovered material as opposed to virgin material. There may be other factors that are influencing the long distances traveled by both materials. This is a topic that could use further research in determining the motivation of companies in buying recovered aluminum from such great distances away from their processing centers.

The exact affects of the transportation used to ship these recovered materials should be researched. How much carbon dioxide and carbon particulates are emitted into the air from the trucks has a large affect on air quality and global climate change. This information would be needed to determine if long distances traveled by each of the products is worth getting the best price or if recycling the materials close to the source would improve the air quality enough to put a value on it greater than the higher monetary value that can be received from processors farther away.

When looking at fuel use it is always important to look at fuel alternatives. Now, the trucks transporting both of the recovered materials are powered by diesel fuel. Research should be done to discover if alternative fuel sources, such as bio-diesel, would have a positive environmental impact as opposed to the petroleum based diesel.

Plastic recyclable material uses more fuel per ton to be transported from Yellowstone National Park to a processor than aluminum recyclable material uses. There are many other factors that must be considered when deciding if PET plastic bottles or aluminum cans would be a more environmentally sustainable choice for Yellowstone National Park. More research is needed to determine all of these factors before recommendations could be made for regulation changes requiring one packaging material over another.

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